

Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California 91109
(818) 354-4321

JPL

27 October 1988

Pam

Dear Principal Investigator:

Enclosed is the document change for Voyager Software Interface Specification, Fixed Instrument SEDR. This change includes updates for the Neptune Encounter.

If there are any questions, please direct them to Neil Toy,
GSDT Team Chief, by calling 354-9436, or writing to him at mail stop
601/110.

Sincerely,



John Schwartz
Data Engineer

JS:lj

Enclosure



DOCUMENT CHANGE NOTICE

Authorized:

Software Change Authorization B763

SIS 4-7008-1 Rev: E Change No.: _____

Date Issued: 10/11/88

Title: Voyager Software Interface

Specification, Fixed Instrument SEDR

Other Documents Affected:

SCA B763-SEDRGEN for Neptune Encounter (Fixed Instrument SEDR).

VOYAGER

SOFTWARE INTERFACE SPECIFICATION

SIS 4-7008-1, Revision E

Fixed Instrument SEDR

11 October 1988

Prepared by: John Schwartz

APPROVALS

GENERATING PROGRAM

SEDRGEN

Cognizant Engineer

Neil Toy 10/11/88

Neil Toy

Cognizant Programmer

Lieu Nguyen

Lieu Nguyen

PRINCIPAL INVESTIGATORS

CONCURRENCE

Neil Toy

Neil Toy

CONCURRENCES

Data Records System Engineer

Neil Toy

Neil Toy

Ground Data System/Software
Engineer

Robert E. Hill

Robert E. Hill

Manager, GDS Engineering

Gary L. Spradlin

Gary L. Spradlin

Number: 4-7008-1, Rev. E
Date: 11 October 1988

SOFTWARE INTERFACE SPECIFICATION

GENERATING PROGRAM:	SEDRGEN	USER PROGRAM:	Fixed Instrument PI SEDR Processor
COMPUTER SYSTEM:	UNIVAC 1100/91	COMPUTER SYSTEM:	

PURPOSE OF INTERFACE:

To provide the fixed or direct sensing instrument Principal Investigators (PI) with navigation and spacecraft orientation information during the periods when their experiment data was obtained.

INTERFACE DEVICE:

The SEDR data will be transmitted to the PIs via a 9-track magnetic tape which has been written at a density of 800 or 1600 bpi using odd lateral parity. Each SEDR tape will contain a single file termed "Fixed Instrument SEDR File".

DATA CODE:

The SEDR will be composed of 32-bit words which contains character, integer and floating point quantities. All character data will be Left Justified Space Filled (LJSF) in the standard IBM EBCDIC code. All integer quantities will be in the 2's complement form. The floating point words will be in the standard IBM format which is given below. In essence the tape will appear as if it had been written on an IBM 360. IBM 360 floating point word has the following 32-bit format:

Bit	0	1	7	8	31		
		SIGN		CHAR		FRACTION	

Where,

SIGN indicates the sign of the quantity represented by the floating point word. If SIGN=0, the quantity is positive. If SIGN=1, the quantity is negative.

CHAR indicates the characteristic or location of the hexadecimal point of the FRACTION portion of the word. This value is normalized to a hexadecimal value of 40 such that CHAR - 40 (hexadecimal arithmetic) locates the hexadecimal point to the right when positive and to the left when negative. The CHAR can also be

considered to be a decimal scale factor which the FRACTION (when evaluated as a decimal) must be multiplied by to properly evaluate the quantity. Under this scheme, the normalized value is 64 (decimal) and the scale factor is the (CHAR - 64)th power of 16.

FRACTION contains the significant digits of the quantity with the binary point located to the left of bit 8.

The following algorithm could be used to evaluate floating point quantities from the format:

$$\text{VALUE}_{10} = (1 - 2 * \text{SIGN}) * (\text{FRACTION}_{10}) * 16_{10}^{*(\text{CHAR}_{10} - 64_{10})}$$

RECORDING METHOD

UNIVAC 1100 System Library Routine, IOW (binary read/write routine)

DETAILED INTERFACE DEFINITION/FORMAT

The SEDRGEN program writes a 9-track magnetic tape at 800 bpi for the PPS, RSS, and UVS experiments and at 1600 bpi for the LECP, PLS, PRA, CRS, IRIS, MAG and PWS experiments. All words will be 32 bits in length and all physical records except for the header record will contain the same number of words for any single SEDR. The attachments to this document describe the structure and content of the Fixed Instrument SEDR File.

- Attachment A Fixed Instrument SEDR File Layout
- Attachment B Fixed Instrument SEDR Header Record Format
- Attachment C Navigation Data Block Format for Launch Period
- Attachment D Navigation Data Block Format for Cruise Periods
- Attachment E Navigation Data Block Format for Jupiter Encounter
- Attachment F Navigation Data Block Format for Saturn Encounter
- Attachment G Pointing Vector Data Block Format
- Attachment H Navigation Data Block Format for Extended Mission Cruise (post Saturn encounter cruise periods)
- Attachment I Navigation Data Block Format for Uranus Encounter
- Attachment J Navigation Data Block Format for Neptune Encounter

DEFINITION OF TERMS

Cartesian State Cartesian position and velocity components in the following order: X-position, Y-position, Z-position, X- velocity, Y-velocity, and Z-velocity.

Celestial Clock and Cone Angles Clock and cone angles centered at the S/C with respect to the sun - S/C - Canopus (ABC) reference system.

Equinox	Refers to the vernal equinox; ie., for the planets the vernal equinox is defined as the axis from the center of the planet to the ascending node of the planet's orbit through the planet's equatorial plane.
Longitudes	The longitude angles given on the SEDR for the planet Systems and satellite will conform to the International Astronomical Union (IAU) conventions. All longitude angles pertaining to Jupiter will be given relative to the System I Prime Meridian. The SEDR will also contain conversion or rotation angles such that longitudes can also be obtained relative to the System II and System III Prime Meridians. This document will not attempt to define all the longitude systems of the planets and satellites that will be represented on the SEDR. However, reference to documentation which contains descriptions of the Jupiter, Saturn, Uranus, and Neptune Systems are given below:
<u>Jupiter System I</u>	Explanatory Supplement to the Ephemeris or JPL Technical Report 32-1508, dated January 15, 1971 (available upon request).
<u>Jupiter System II</u>	Same as Jupiter System I.
<u>Jupiter System III</u>	The SEDR uses System III (1965.0)
<u>Saturn System</u>	JPL Technical Report 32-1508, dated January 15, 1971 (available upon request).
<u>Uranus System</u>	JPL Interoffice Memorandum, Voyager-NAV-84-42, "Trajectory/Navigation Data Package for Nominal Voyager 2 Uranus-System Flyby", dated August 31, 1984 (available upon request).
<u>Neptune System</u>	VOYAGER MISSION DESIGN GUIDELINES & CONSTRAINTS, PD 618-123, Vol. IV, Subsection 50.5, Issue 18, 29 August 1988.

List of Acronyms

BPI	Bits per inch
C	Character quantity
CRS	Cosmic Ray Subsystem
Deg	Degrees
Dim	Dimensionless
DPTRAJ	Double Precision Trajectory Program
E	Floating point quantity
FDSC	Flight Data Subsystem count
FIP	Fixed Instrument Pointing
GMT	Greenwich Mean Time
HHMMSS	Hours-minutes-seconds
I	Integer quantity
IAU	International Astronomical Union
IPPS	Instrument Pointing Program Set
IRG	Inter-record gap
IRIS	Infrared Interferometer Spectrometer and Radiometer Subsystem
JPL	Jet Propulsion Laboratory
Km	Kilometer
Km/sec	Kilometers per second
LECP	Low Energy Charged Particle Subsystem
LJSF	Left Justified Space Filled
MMDDYY	Month-day-year
MOD	Modulo
Msec	Milliseconds
PI	Principal Investigator

PLS Plasma Subsystem
PPS Photopolarimeter Subsystem
PRA Planetary Radio Astronomy Subsystem
PWS Plasma Science Subsystem
RSS Radio Science Subsystem
SCET Spacecraft event time
Sec Seconds
SEDR Supplementary Experiment Data Records
SEDRGEN Supplementary Experiment Data Records Generation Program
S/C Spacecraft
UTC Coordinated Universal Time
UVS Ultraviolet Spectrometer Subsystem

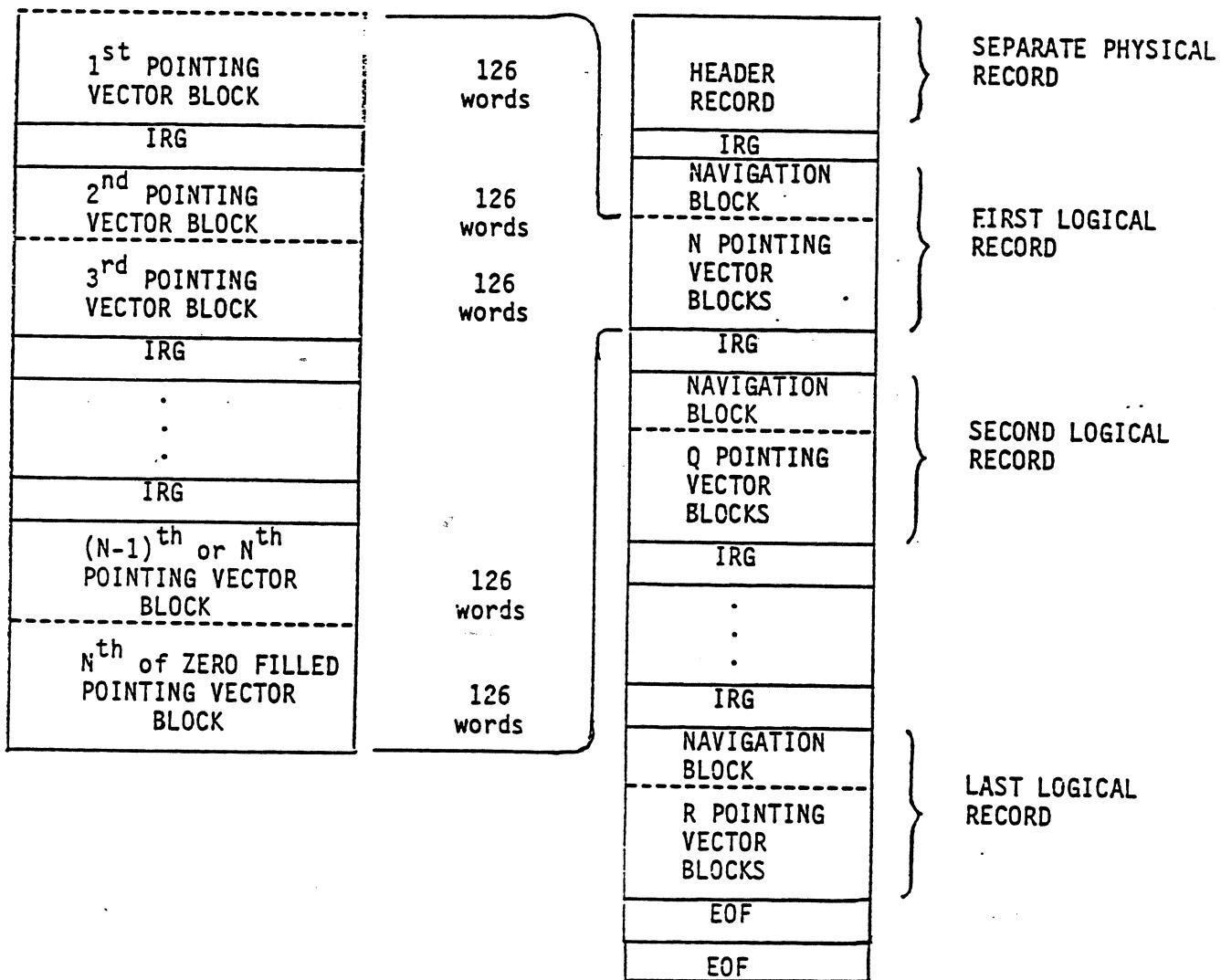
ATTACHMENT A

**Fixed Instrument SEDR
File Layout**

ATTACHMENT A

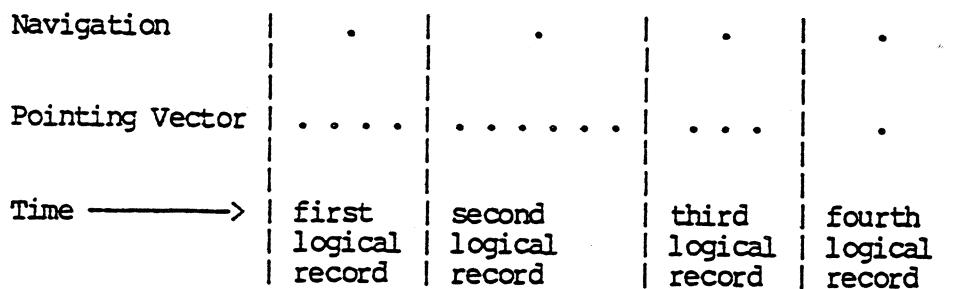
Fixed Instrument SEDR File Layout

The following SEDR file (tape) layout represents the common file structure that will be supplied to fixed instrument Principal Investigators (PIs) of the Voyager mission.



Each logical record will contain one navigation data block (one set of navigation data effective at a particular time) and all pointing vector data blocks associated with it. This association is determined by time such that the times of the pointing vector blocks in any logical record are closer to that logical record's navigation block time than any other navigation block time on the SEDR. The following figure illustrates how SEDR logical records

would be formed given an arbitrary set of navigation and pointing vector times. Note that the navigation block is always the first data in the logical record even though some of the pointing vector blocks may have earlier times. However, the navigation and pointing vector blocks taken as individual sets will always be in increasing time order.



Each logical record will be composed of an integral number of physical records. Also, each physical record will contain an integral number of 126 word logical blocks. The number of these blocks for each physical record will be determined from the size of the navigation data block and one pointing vector block. For launch, cruise, and Saturn encounter, the navigation data block occupies one logical block while the Jupiter and Uranus encounter navigation blocks require two logical blocks. The pointing vector block is mission phase independent and always occupies one logical block. Therefore, the physical record size for launch, cruise, and Saturn encounter is 2 logical blocks or 252 words while Jupiter or Uranus encounter requires 3 logical blocks or 378 words. When multiple pointing vector blocks exist in a logical record, these data are filled into as many additional physical records as are required to contain the logical record. Each pointing vector block will contain a continuation bit which indicates if that pointing vector block is the last block in the logical record. If the last physical record is not evenly filled with pointing vector blocks, the remainder of the record will be zero filled. The left-hand portion of the file format presented at the start of this attachment illustrates the physical record - logical record structure/relationship for the launch, cruise, or Saturn encounter format. The Jupiter, Uranus and Neptune encounter formats would be similar except that the physical records would contain three 126 word blocks instead of two.

ATTACHMENT B

**Fixed Instrument SEDR
Header Record Format**

ATTACHMENT B

Fixed Instrument SEDR Header Record Format

WORD	DESCRIPTION	UNITS	TYPE
1	Project Identification	'VOY 77'	C
2	File Identification	'SEDR'	C
3	S/C Identification 0 = Flt 2, 1 = Flt 1, 2 = PTM, 4 = Sim 1, 5 = Sim 2, Others = Unused	dim	I
4-5	SEDR Tape Identification	see page 12	C
6	SEDR File Generation Date	MMDDYY	I
7	SEDR File Generation Time	HHMMSS	I
8-9	Pointing Vector (FIP) Tape Identification	JPL Facility Number	C
10	FIP File Generation Data	MMDDYY	I
11	FIP File Generation Time	HHMMSS	I
12-13	Navigation (DPTRAJ Save Tape) Tape Identification	JPL Facility Number	C
14-15	Navigation Data Block Identification, i.e., Launch, Cruise, Jupiter or Saturn	'LAUNCH' 'CRUISE' 'JUPITE' 'SATURN' 'XCRUIS' 'URANUS' 'NEPTUN'	C

ATTACHMENT B

Fixed Instrument SEDR Header Record Format

SEDR TAPE IDENTIFICATION

Each SEDR tape is labelled with an eight character alphanumeric identifier which indicates the SEDR type, the experiment/instrument identification, the spacecraft identification and the mission phase. The identifier has the following general form:

A B B I J J K K

- A indicates the SEDR type. A = S, indicates a fixed instrument SEDR and A = F, indicates a scan platform or footprint SEDR.
- BB indicates the experiment/instrument identification according to the following list:

<u>BB</u>	<u>Experiment/Instrument</u>
CR	Cosmic Ray
IR	Infrared Interferometer Spectrometer
LE	Low Energy Charged Particles
MA	Magnetometer
PL	Plasma
PP	Photopolarimeter
PR	Planetary Radio Astronomy
PW	Plasma Wave
RS	Radio Science
UV	Ultra Violet Spectrometer

- I indicates the spacecraft identification. I = 0 is for the FLT-2 spacecraft and I = 1 is for the FLT-1 spacecraft.
- JJ indicates the mission phase according to the following list:

<u>JJ</u>	<u>Mission Phase</u>
00-09	Unused
10-19	Launch
20-29	Earth to Jupiter Cruise
30-39	Jupiter Encounter
40-49	Jupiter to Saturn Cruise
50-59	Saturn Encounter
60-69	Post Saturn or Saturn to Uranus Cruise
70-79	Uranus Encounter
80-89	Post Uranus or Uranus to Neptune Cruise
90-99	Neptune Encounter

KK Indicates the SEDR serial number within each mission phase.

ATTACHMENT C

**Navigation Data Block Format
for Launch Period**

Navigation Data Block Format for Launch Period

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute o hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Navigation Data Block Format for Launch Period

WORD	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49	Range Earth - S/C	km	E
50	Range Earth - Sun	km	E
51	Range Sun - S/C	km	E
52	Range Jupiter - S/C	km	E
53	Range Saturn - S/C	km	E
54	Range Sun - Jupiter	km	E
55	Range Sun - Saturn	km	E
56	Angle Earth - Sun - S/C	deg	E
57	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E

Navigation Data Block Format for Launch Period

WORD	DESCRIPTION	UNITS	TYPE
58	Angle Sun - Earth - S/C	deg	E
59	Angle Jupiter - Sun - S/C	deg	E
60	Angle Sun - S/C - Jupiter (Celestial Cone Angle of Jupiter)	deg	E
61	Angle Sun - Jupiter - S/C	deg	E
62	Angle Saturn - Sun - S/C	deg	E
63	Angle Sun - S/C - Saturn (Celestial Cone Angle of Saturn)	deg	E
64	Angle Sun - Saturn - S/C	deg	E
65	Celestial Clock Angle of Earth	deg	E
66	Celestial Clock Angle of Jupiter	deg	E
67	Celestial Clock Angle of Saturn	deg	E
68-69	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E

ATTACHMENT C

Navigation Data Block Format for Launch Period

WORD	DESCRIPTION	UNITS	TYPE
70-71	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
72-73	Right Ascension and Declination of Jupiter, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
74-75	Right Ascension and Declination of Saturn, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
76-77	Right Ascension and Declination of S/C, Jupiter Centered Jupiter True Equinox and Equator of Date	deg	E
78-79	Right Ascension and Declination of Sun, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
80-81	Right Ascension and Declination of Earth, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
82-83	Right Ascension and Declination of Io, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
84-85	Right Ascension and Declination of S/C, Saturn Centered, Saturn Mean Equinox and Equator of 1950.0	deg	E
86-87	Spares		
88-89	Spares		
90-91	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

Navigation Data Block Format for Launch Period

WORD	DESCRIPTION	UNITS	TYPE
92-93	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
94-95	Celestial Latitude and Longitude of Jupiter, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
96-97	Celestial Latitude and Longitude of Saturn, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
98-99	Right Ascension and Declination of S/C, Sun Centered, Sun True Equinox and Equator of Date	deg	E
100-101	Right Ascension and Declination of Earth, Sun Centered, Sun True Equinox and Equator of Date	deg	E
102-103	Right Ascension and Declination of Jupiter, Sun Centered, Sun True Equinox and Equator of Date	deg	E
104-105	Right Ascension and Declination of Saturn, Sun Centered, Sun True Equinox and Equator of Date	deg	E
106	Hour Angle of Jupiter System III Prime Meridian, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
107-126	Spares		

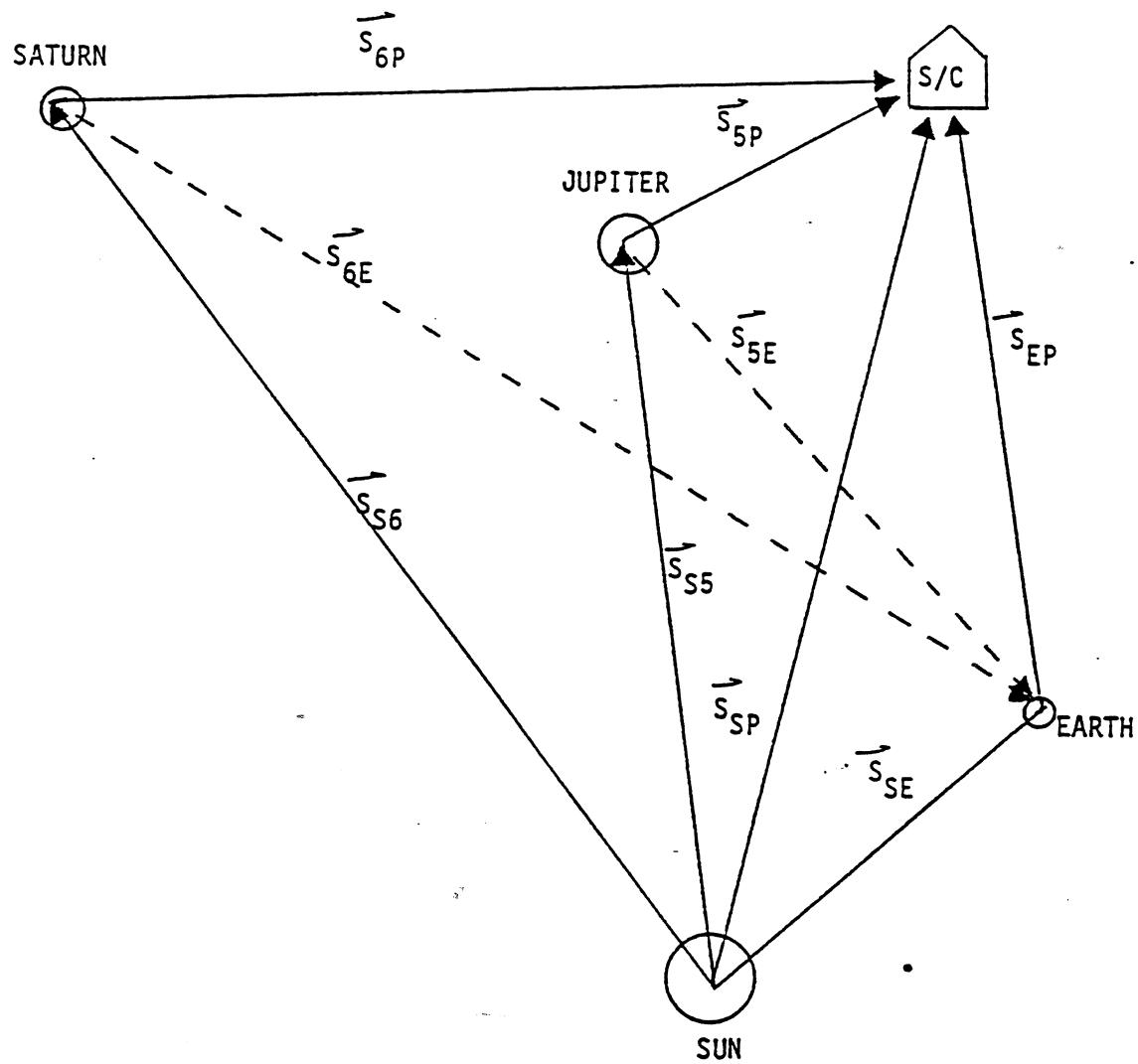


Figure C-1 Earth Mean Ecliptic and
Equinox of 1950.0 (ECL50)
Launch SEDR State Vectors

Nomenclature → \vec{S} refers to State Vector (Position and Velocity Components) with the subscripts AB, where, A is the reference or "From" body and B is the "To" body. The following body definitions are used; S-Sun, P-S/C or Probe, E-Earth, 5-Jupiter and 6-Saturn.

Note that the Earth State with respect to Jupiter and Saturn (\vec{S}_{5E} and \vec{S}_{6E} - dashed vectors in Figure) will not be provided. These states can be simply derived, if desired, by the PI by vector subtraction of the Sun to Earth State (\vec{S}_{SE}) and the Sun to Jupiter and the Sun to Saturn States (\vec{S}_{SS5} and \vec{S}_{SS6}).

ATTACHMENT D

**Navigation Data Block Format
for Cruise Periods**

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

ATTACHMENT D

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49	Range Earth - S/C	km	E
50	Range Earth - Sun	km	E
51	Range Sun - S/C	km	E
52	Range Jupiter - S/C	km	E
53	Range Saturn - S/C	km	E
54	Range Sun - Jupiter	km	E
55	Range Sun - Saturn	km	E
56	Angle Earth - Sun - S/C	deg	E
57	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E

ATTACHMENT D

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
58	Angle Sun - Earth - S/C	deg	E
59	Angle Jupiter - Sun - S/C	deg	E
60	Angle Sun - S/C - Jupiter (Celestial Cone Angle of Jupiter)	deg	E
61	Angle Sun - Jupiter - S/C	deg	E
62	Angle Saturn - Sun - S/C	deg	E
63	Angle Sun - S/C - Saturn (Celestial Cone Angle of Saturn)	deg	E
64	Angle Sun - Saturn - S/C	deg	E
65	Celestial Clock Angle of Earth	deg	E
66	Celestial Clock Angle of Jupiter	deg	E
67	Celestial Clock Angle of Saturn	deg	E
68-69	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E

ATTACHMENT D

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
70-71	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
72-73	Right Ascension and Declination of Jupiter, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
74-75	Right Ascension and Declination of Saturn, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
76-77	Right Ascension and Declination of S/C, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
78-79	Right Ascension and Declination of Sun, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
80-81	Right Ascension and Declination of Earth, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
82-83	Right Ascension and Declination of Io, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
84-85	Right Ascension and Declination of S/C, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
86-87	Right Ascension and Declination of Sun, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
88-89	Right Ascension and Declination of Earth, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
90-91	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

ATTACHMENT D

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
92-93	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
94-95	Celestial Latitude and Longitude of Jupiter, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
96-97	Celestial Latitude and Longitude of Saturn, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
98-99	Right Ascension and Declination of S/C, Sun Centered, Sun True Equinox and Equator of Date	deg	E
100-101	Right Ascension and Declination of Earth, Sun Centered, Sun True Equinox and Equator of Date	deg	E
102-103	Right Ascension and Declination of Jupiter, Sun Centered, Sun True Equinox and Equator of Date	deg	E
104-105	Right Ascension and Declination of Saturn, Sun Centered, Sun True Equinox and Equator of Date	deg	E
106	Hour Angle of Jupiter System III Prime Meridian, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
107-126	Spares		

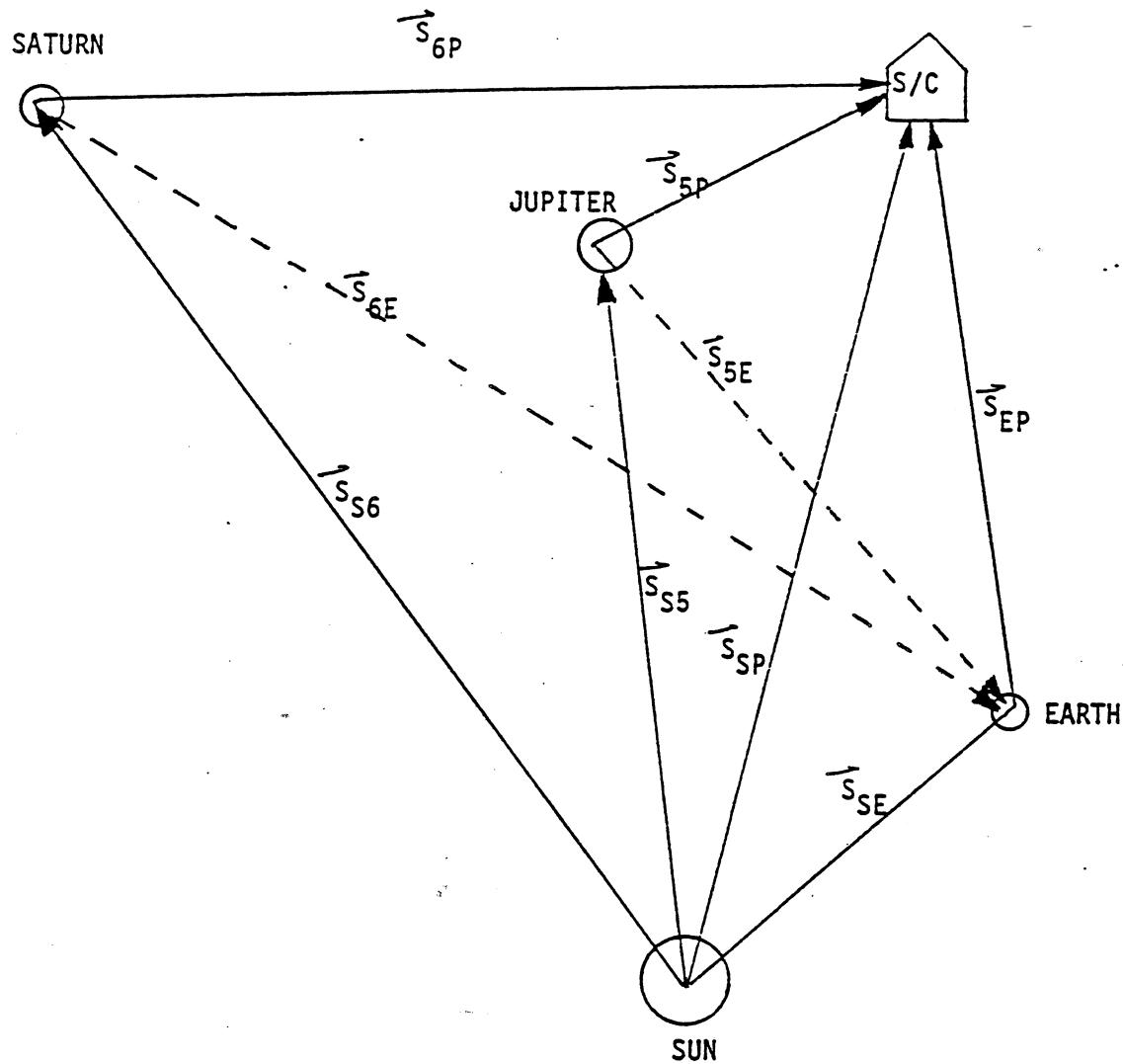


Figure D-1 Earth Mean Ecliptic and
Equinox of 1950.0 (ECL50)
Cruise SEDR State Vectors

Nomenclature $\rightarrow \vec{S}$ refers to State Vector (Position and Velocity Components) with the subscripts AB, where, A is the reference or "From" body and B is the "To" body. The following body definitions are used; S-Sun, P-S/C or Probe, E-Earth, 5-Jupiter and 6-Saturn

Note that the Earth State with respect to Jupiter and Saturn (\vec{S}_{5E} and \vec{S}_{6E} - dashed vectors in Figure) will not be provided. These states can be simply derived, if desired, by the PI by vector subtraction of the Sun to Earth State (\vec{S}_{SE}) and the Sun to Jupiter and the Sun to Saturn States (\vec{S}_{S5} and \vec{S}_{S6}).

ATTACHMENT E

**Navigation Data Block Format
for Jupiter Encounter**

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Io Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of S/C, Europa Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of S/C, Ganymede Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of S/C, Callisto Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49-54	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
61-66	Cartesian State of Earth, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
67-72	Cartesian State of Io, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
73-78	Cartesian State of Europa, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
79-84	Cartesian State of Ganymede, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
85-90	Cartesian State of Callisto, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
91-96	Cartesian State of S/C, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
97-102	Cartesian State of Io, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
103-108	Cartesian State of Europa, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
109-114	Cartesian State of Ganymede, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
115-120	Cartesian State of Callisto, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
121-126	Cartesian State of S/C, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km km/sec	E
127-129	Cartesian Position of Io, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
130-132	Cartesian Position of Europa, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
133-135	Cartesian Position of Ganymede, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
136-138	Cartesian Position of Callisto, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
139-144	Cartesian State of S/C, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km km/sec	E
145-147	Cartesian Position of Io, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
148-150	Cartesian Position of Europa, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E

ATTACHMENT E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
151-153	Cartesian Position of Ganymede, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
154-156	Cartesian Position of Callisto, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
157-159	Jupiter Latitude, System I Longitude and System III Longitude of S/C	deg	E
160-162	Jupiter Latitude; System I Longitude and System III Longitude of Io	deg	E
163-165	Jupiter Latitude, System I Longitude and System III Longitude of Europa	deg	E
166-168	Jupiter Latitude, System I Longitude and System III Longitude of Ganymede	deg	E
169-171	Jupiter Latitude, System I Longitude and System III Longitude of Callisto	deg	E
172	Range Earth - S/C	km	E
173	Range Sun - S/C	km	E
174	Range Sun - Earth	km	E
175	Range Sun - Jupiter	km	E

ATTACHMENT E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION		UNITS	TYPE
176	Range	Jupiter - S/C	km	E
177	Range	Jupiter - Io	km	E
178	Range	Jupiter - Europa	km	E
179	Range	Jupiter - Ganymede	km	E
180	Range	Jupiter - Callisto	km	E
181	Angle	Earth - Sun - S/C	deg	E
182	Angle	Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
183	Angle	Sun - Earth - S/C	deg	E
184	Angle	Jupiter - Sun - S/C	deg	E
185	Angle	Sun - S/C - Jupiter (Celestial Cone Angle of Jupiter)	deg	E
186	Angle	Sun - Jupiter - S/C	deg	E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
187	Celestial Clock Angle of Earth	deg	E
188	Celestial Clock Angle of Jupiter	deg	E
189-190	Celestial Clock and Cone Angles of Io	deg	E
191-192	Celestial Clock and Cone Angles of Europa	deg	E
193-194	Celestial Clock and Cone Angles of Ganymede	deg	E
195-196	Celestial Clock and Cone Angles of Callisto	deg	E
197-198	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
199-200	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
201-202	Right Ascension and Declination of Jupiter, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
203-204	Right Ascension and Declination of S/C, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
205-206	Right Ascension and Declination of Sun, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
207-208	Right Ascension and Declination of Io, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
209-210	Right Ascension and Declination of Europa, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
211-212	Right Ascension and Declination of Ganymede, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
213-214	Right Ascension and Declination of Callisto, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
215-216	Celestial Latitude and Longitude of S/C, Sun Centered; Earth True Equinox and Ecliptic of Date	deg	E
217-218	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
219-220	Celestial Latitude and Longitude of Jupiter, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
221-226	Cartesian State of S/C, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	km km/sec	E
227-232	Cartesian State of Io, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	km	E
233	Range Jupiter Magnetic Dipole - S/C	km	E
234	Range Jupiter Magnetic Dipole - Io	km	E

Navigation Data Block Format for Jupiter Encounter

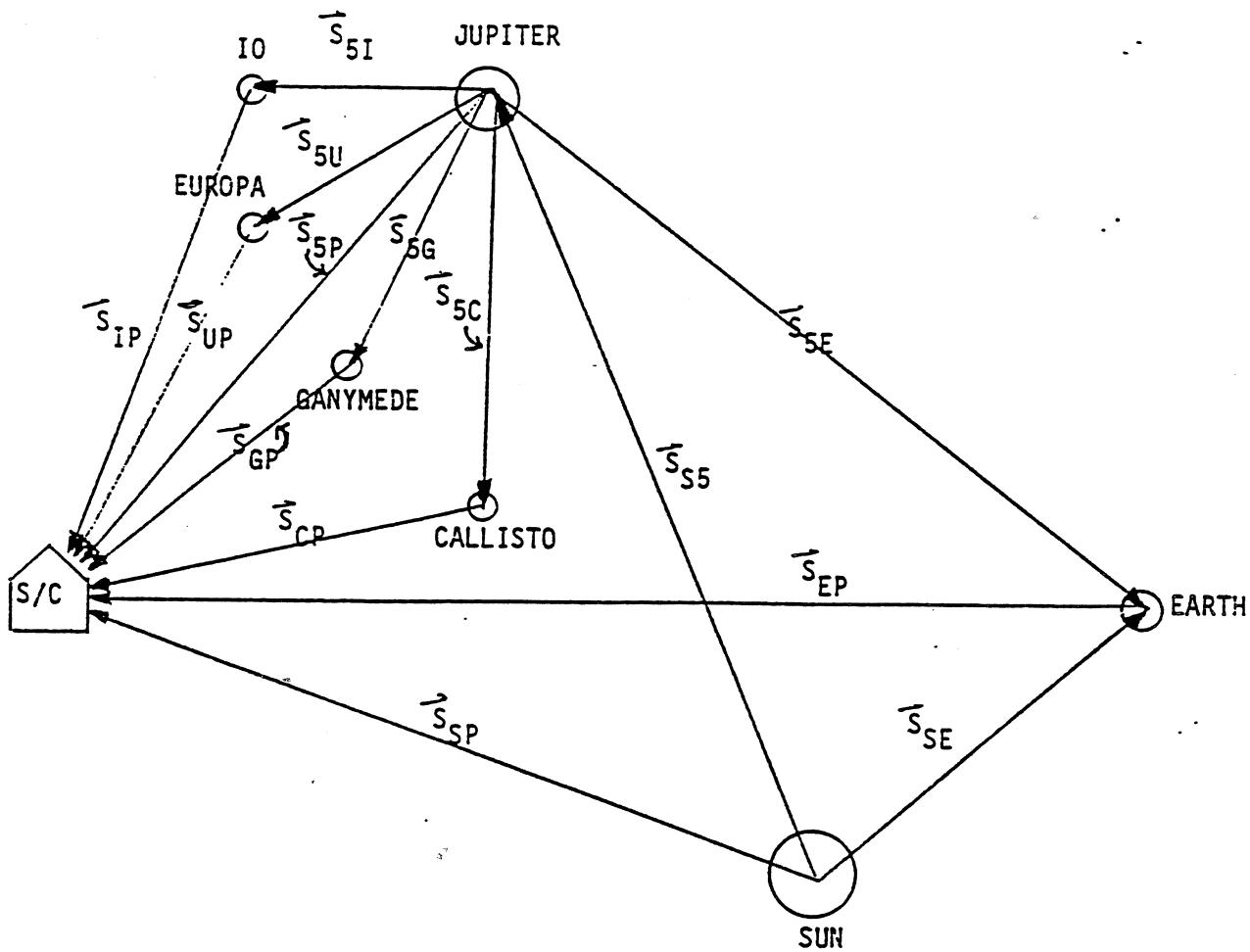


Figure E-1 Earth Mean Ecliptic and
Equinox of 1950.0 (ECL50)
Jupiter Encounter State
Vectors

Nomenclature → \vec{S} refers to State Vector (Position and Velocity Components) with the subscripts AB, where A is the reference or "From" body and B is the "To" body. The following body definitions are used:
S-Sun, P-S/C or Probe, E-Earth, 5-Jupiter,
I-Io, U-Europa, G-Ganymede, C-Callisto.

ATTACHMENT F

**Navigation Data Block Format
for Saturn Encounter**

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Titan Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Earth, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49-54	Cartesian State of Titan, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of S/C, Saturn Centered, Saturn Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
61-66	Cartesian State of Titan, Saturn Centered, Saturn Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
67-72	Cartesian State of S/C, Saturn Centered, Saturn True Prime Meridian and Equator of Date	km km/sec	E
73-75	Cartesian Position of Titan, Saturn Centered, Saturn True Prime Meridian and Equator of Date	km	E
76-77	Saturn Latitude and Longitude of S/C	deg	E
78-79	Saturn Latitude and Longitude of Titan	deg	E
80	Range Earth - S/C	km	E
81	Range Earth - Sun	km	E

ATTACHMENT F

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
82	Range Sun - S/C	km	E
83	Range Saturn - S/C	km	E
84	Range Titan - S/C	km	E
85	Range Sun - Saturn	km	E
86	Range Saturn - Titan	km	E
87	Angle Earth - Sun - S/C	deg	E
88	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
89	Angle Sun - Earth - S/C	deg	E
90	Angle Saturn - Sun - S/C	deg	E
91	Angle Sun - S/C - Saturn (Celestial Cone Angle of Saturn)	deg	E
92	Angle Sun - Saturn - S/C	deg	E

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
93	Celestial Clock Angle of Earth	deg	E
94	Celestial Clock Angle of Saturn	deg	E
95-96	Celestial Clock and Cone Angles of Titan	deg	E
97-98	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
99-100	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
101-102	Right Ascension and Declination of Saturn, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
103-104	Right Ascension and Declination of S/C, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
105-106	Right Ascension and Declination of Sun, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
107-108	Right Ascension and Declination of Titan, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
109-110	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
111-112	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

ATTACHMENT F

Navigation Data Block Format for Saturn Encounter

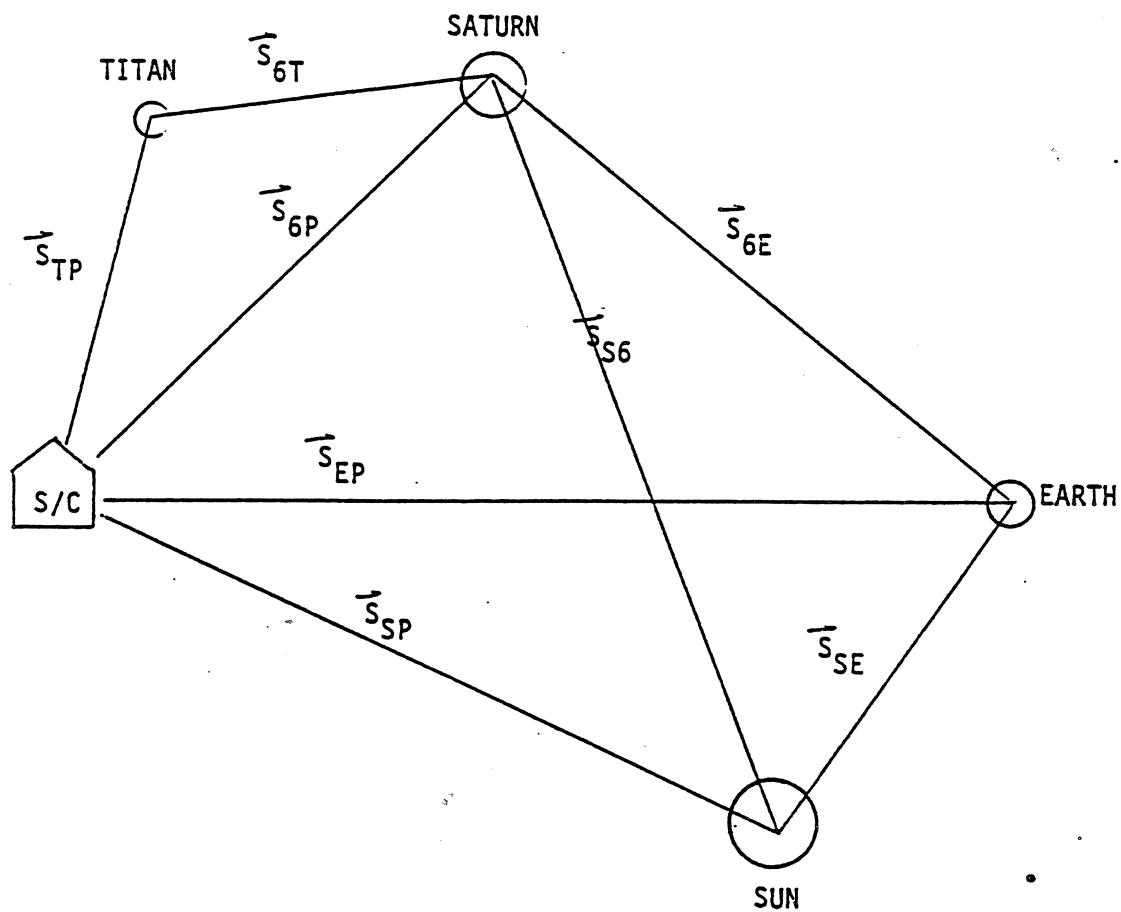


Figure F-1 Earth Mean Ecliptic and
Equinox of 1950.0 (ECL50)
Saturn Encounter State
Vectors

Nomenclature → \vec{S} refers to State Vector (Position and Velocity Components) with the subscripts AB, where A is the reference or "From" body and B is the "To" body. The following body definitions are used:
 S-Sun, P-S/C or Probe, E-Earth, 6-Saturn,
 T-Titan.

ATTACHMENT G

**Pointing Vector Data
Block Format**

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Pointing Vector Data Block	years, AD	I
2	SCE GMT Day of Pointing Vector Data Block	day of year	I
3	SCE GMT Hour of Pointing Vector Data Block	hour of day	I
4	SCE GMT Minute of Pointing Vector Data Block	minute of hour	I
5	SCE GMT Second of Pointing Vector Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Pointing Vector Data Block	msec of second	I
7	FDSC MOD16 Count Value of Pointing Vector Data Block	binary counts	I
8	FDSC MOD60 Count Value of Pointing Vector Data Block	binary counts	I
9	Pitch Limit Cycle Angle (Rotation about the S/C X-Axis with the positive direction determined by the right hand rule)	deg	E
10	Yaw Limit Cycle Angle (Rotation about the S/C Y-Axis with the Positive direction determined by the right hand rule)	deg	E
11	Roll Limit Cycle Angle (Rotation about the S/C Z-Axis with the positive direction determined by the right hand rule)	deg	E

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
12-14	Cartesian Unit Vector of the S/C X-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
15-17	Cartesian Unit Vector of the S/C Y-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
18-20	Cartesian Unit Vector of the S/C Z-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
21-22	Celestial Clock and Cone Angles of CRS LET C Boresight	deg	E
23-25	Cartesian Unit Vector of the CRS LET C Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
26-27	Celestial Clock and Cone Angles of the CRS LET A Boresight	deg	E
28-30	Cartesian Unit Vector of the CRS LET A Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
31-32	Celestial Clock and Cone Angles of the CRS LET D Boresight	deg	E
33-35	Cartesian Unit Vector of the CRS LET D Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
36-37	Celestial Clock and Cone Angles of the CRS LET B Boresight	deg	E
38-40	Cartesian Unit Vector of the CRS LET B Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
41-42	Celestial Clock and Cone Angles of the CRS TET Boresight	deg	E
43-45	Cartesian Unit Vector of the CRS TET Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
46-47	Celestial Clock and Cone Angles of the CRS HET 1 Boresight	deg	E
48-50	Cartesian Unit Vector of the CRS HET 1 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
51-52	Celestial Clock and Cone Angles of the CRS HET 21* Boresight	deg	E
53-55	Cartesian Unit Vector of the CRS HET 21 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
56-57	Celestial Clock and Cone Angles of the CRS HET 22* Boresight	deg	E
58-60	Cartesian Unit Vector of the CRS HET 22 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
61-62	Celestial Clock and Cone Angles of the LECP Axis of Rotation	deg	E
63-65	Cartesian Unit Vector of the LECP Axis of Rotation, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
66-67	Celestial Clock and Cone Angles of the PLS Axis of Symmetry	deg	E

* HET 2, Positions 1 and 2, i.e., HET 21 and HET 22.

ATTACHMENT G

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
68-70	Cartesian Unit Vector of the PLS Axis of Symmetry, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0.	dim	E
71-72	Celestial Clock and Cone of the PLS Lateral Detector Boresight	deg	E
73-75	Cartesian Unit Vector of the PLS Lateral Detector Boresight, S/C Centered, Earth Mean Ecliptic And Equinox of 1950.0	dim	E
76-77	Celestial Clock and Cone Angles of the HGA Boresight	deg	E
78-80	Cartesian Unit Vector of the HGA Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
81-82	Celestial Clock and Cone Angles of the PPS Optic Axis	deg	E
83-85	Cartesian Unit Vector of the PPS Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
86-87	Celestial Clock and Cone Angles of the UVS Airglow Optic Axis	deg	E
88-90	Cartesian Unit Vector of the UVS Airglow Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
91-92	Celestial Clock and Cone Angles of the UVS Occultation Optic Axis	deg	E
93-95	Cartesian Unit Vector of the UVS Occultation Optic Axis, S/C Centered Earth Mean Ecliptic and Equinox of 1950.0	dim	E

ATTACHMENT G

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
96-97	Celestial Clock and Cone Angles of the IRIS Optic Axis	deg	E
98-100	Cartesian Unit Vector of the IRIS Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
101	Continuation Bit: = 1, another pointing vector block follows = 0, last pointing vector block in this logical record	dim	I
102	Scan Platform Azimuth Angle	deg	E
103	Scan Platform Elevation Angle	deg	E
104	Telemetry Use Code (Octal)* 0 = telemetry is NOT used or predict is used 1 = telemetry is used	NA	Octal
105-126	Spares		

* Refer to Table G-2 for breakdown of telemetry code.

TABLE G-1

Nominal S/C Clock and Cone Angles
of the Fixed Instrument Boresights

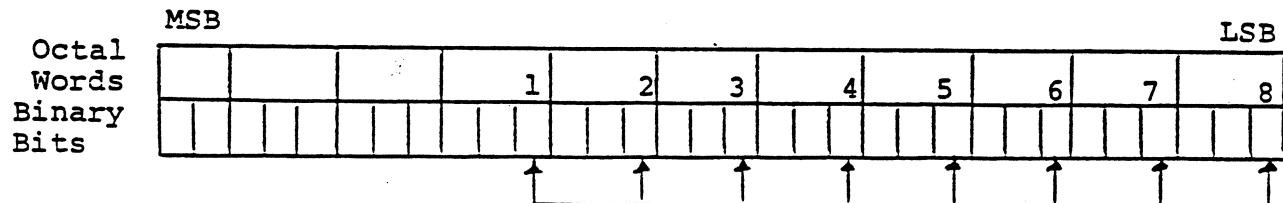
BORESIGHT	S/C CLOCK AND CONE ANGLES*	
	CLOCK (deg)	CONE (deg)
CRS LET A	305	115
CRS LET B	236	53
CRS LET C	125	65
CRS LET D	10	48
CRS TET	305	115
CRS HET 1	338	60
CRS HET 21	104	78
CRS HET 22	104	140
LECP Axis of Rotation	200	90
PLS Axis of Symmetry	---	0
PLS Lateral Detector	262	90
HGA	---	0

*S/C clock and cone angles are not to be confused with celestial clock and cone angles. The S/C clock/cone system uses the HGA boresight and the Canopus Tracker optic axis as references while the celestial clock/cone system uses the Sun and Canopus.

Table G-2
TELEMETRY USE CODE

OCTAL NUMBER POSITION - LEFT TO RIGHT	DESCRIPTION
1 *	Pitch Limit Cycle Position
2 *	Yaw Limit Cycle Position
3 *	Roll Limit Cycle Position
4	Scan Platform Elevation
5	Scan Platform Azimuth
6	Pitch Limit Cycle Rate
7	Yaw Limit Cycle Rate
8	Roll Limit Cycle Rate

* always zero if no limit cycle correction is applied.



When these bits are set telemetry is used.
When they are not set predicts are used.
All other bits are zero.

RIGHT ASCENSION AND DECLINATION ALGORITHM

The PI may wish to compute S/C centered right ascension and declination angles of his boresight or optic axis relative to the Earth Mean Equator and Equinox of 1950.0 (EME50). To obtain these angles the following two step algorithm is offered.

Step 1. Rotate ECL50 Unit Vector to EME50 Unit Vector

The instrument boresight or optic axis unit vector is available from the SEDR relative to the Earth Mean Ecliptic and Equinox of 1950.0 (ECL50). This unit vector must be rotated through the mean obliquity of the ecliptic (angle between the ecliptic and equatorial planes) at 1950.0 to obtain the EME50 unit vector. The following transformation matrix will accomplish the required rotation.

$$\begin{array}{ccc} & & \\ \text{ECL50} & & \\ T \downarrow & = & \\ \text{EME50} & & \end{array} \quad \left[\begin{array}{ccc} 1 & 0 & 0 \\ 0 & \cos \bar{\epsilon}_o & -\sin \bar{\epsilon}_o \\ 0 & \sin \bar{\epsilon}_o & \cos \bar{\epsilon}_o \end{array} \right]$$

Where $\bar{\epsilon}_o$ is the mean obliquity of the ecliptic at 1950.0 and $\bar{\epsilon}_o = 23.445789^\circ$. The following example illustrates the proper use of this matrix.

$$\overline{U}_{\text{EME50}} = T \begin{array}{c} \text{ECL50} \\ \downarrow \\ \text{EME50} \end{array} * \overline{U}_{\text{ECL50}}$$

Where $\overline{U}_{\text{EME50}}$ and $\overline{U}_{\text{ECL50}}$ are the EME50 and ECL50 unit vectors,

respectively, and $T \begin{array}{c} \text{ECL50} \\ \downarrow \\ \text{EME50} \end{array}$ is the transformation matrix.

Step 2. Compute the Right Ascension and Declination Angles

Once the unit vector has been transformed to EME50 coordinates, the right ascension and declination angles can be computed by using the following equations:

$$\alpha = \tan^{-1} (y_{\text{EME50}} / x_{\text{EME50}})$$

$$\delta = \sin^{-1} (z_{\text{EME50}})$$

Where α is the right ascension angle, δ is the declination angle and x_{EME50} , y_{EME50} and z_{EME50} are the x, y and z components of the EME50 unit vector.

Attachment H

ATTACHMENT H

**Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block
Post-Saturn Cruise**

Attachment H

Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of day	I
5	SCE GMT Second of Navigation Data Block	second of min	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Uranus Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Attachment H

Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block

WORD	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of Uranus, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Neptune, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49	Range Earth - S/C	km	E
50	Range Earth - Sun	km	E
51	Range Sun - S/C	km	E
52	Range Uranus - S/C	km	E
53	Range Neptune - S/C	km	E
54	Range Sun - Uranus	km	E
55	Range Sun - Neptune	km	E
56	Angle Earth - Sun - S/C	deg	E
57	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E

57

Attachment H

Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block

WORD	DESCRIPTION	UNITS	TYPE
58	Angle Sun - Earth - S/C	deg	E
59	Angle Uranus - Sun - S/C	deg	E
60	Angle Sun - S/C - Uranus (Celestial Cone Angle of Uranus)	deg	E
61	Angle Sun - Uranus - S/C	deg	E
62	Angle Neptune - Sun - S/C	deg	E
63	Angle Sun - S/C - Neptune (Celestial Cone Angle of Neptune)	deg	E
64	Angle Sun - Neptune - S/C	deg	E
65	Celestial Clock Angle of Earth	deg	E
66	Celestial Clock Angle of Uranus	deg	E
67	Celestial Clock Angle of Neptune	deg	E
68-69	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E

Attachment II

Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block

WORD	DESCRIPTION	UNITS	TYPE
70-71	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
72-73	Right Ascension and Declination of Uranus, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
74-75	Right Ascension and Declination of Neptune, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
76-77	Right Ascension and Declination of S/C, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
78-79	Right Ascension and Declination of Sun, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
80-81	Right Ascension and Declination of Earth, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
82-83	Spare Words		
84-85	Right Ascension and Declination of S/C, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
86-87	Right Ascension and Declination of Sun, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
88-89	Right Ascension and Declination of Earth, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
90-91*	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

* Planetocentric latitude

Attachment H

Fixed Instrument SEDR Format
Extended Mission Cruise Navigation Block

WORD	DESCRIPTION	UNITS	TYPE
92-93*	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
94-95*	Celestial Latitude and Longitude of Uranus, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
96-97*	Celestial Latitude and Longitude of Neptune Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
98-99	Right Ascension and Declination of S/C, Sun Centered, Sun True Equinox and Equator of Date	deg	E
100-101	Right Ascension and Declination of Earth, Sun Centered, Sun True Equinox and Equator of Date	deg	E
102-103	Right Ascension and Declination of Uranus, Sun Centered, Sun True Equinox and Equator of Date	deg	E
104-105	Right Ascension and Declination of Neptune, Sun Centered, Sun True Equinox and Equator of Date	deg	E
106-111	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
112-117	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
118-126	Spare Words		

* Planetocentric latitude

Attachment I

ATTACHMENT I

**Fixed Instrument SEIR Format
Uranus Encounter Navigation Block**

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of min	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Uranus Centered, Earth Mean Ecliptic Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Miranda Centered, Earth Mean Ecliptic Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of S/C, Ariel Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of S/C, Umbriel Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of S/C, Titania Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49-54	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of Uranus, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
61-66	Cartesian State of Earth, Uranus Centered, Earth Mean Ecliptic Equinox of 1950.0	km km/sec	E
67-72	Cartesian State of Miranda, Uranus Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
73-78	Cartesian State of Ariel, Uranus Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
79-84	Cartesian State of Umbriel, Uranus Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
85-90	Cartesian State of Titania, Uranus Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
91-96	Cartesian State of S/C, Uranus Centered, Uranus Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
97-102	Cartesian State of Miranda, Uranus Centered, Uranus Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
103-108	Cartesian State of Ariel, Uranus Centered, Uranus Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
109-114	Cartesian State of Umbriel, Uranus Centered, Uranus Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
115-120	Cartesian State of Titania, Uranus Centered, Uranus Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
121-126	Cartesian State of S/C, Uranus Centered, Uranus True Prime Meridian and Equator of Date	km km/sec	E
127-129	Cartesian Position of Miranda, Uranus Centered, Uranus True Prime Meridian and Equator of Date	km	E
130-132	Cartesian Position of Ariel, Uranus Centered, Uranus True Prime Meridian and Equator of Date	km	E
133-135	Cartesian Position of Umbriel, Uranus Centered, Uranus True Prime Meridian and Equator of Date	km	E
136-138	Cartesian Position of Titania, Uranus Centered, Uranus True Prime Meridian and Equator of Date	km	E
139-140	Uranus Latitude*, Longitude of S/C	deg	E
141-142	Uranus Latitude*, Longitude of Miranda	deg	E
143-144	Uranus Latitude*, Longitude of Ariel	deg	E

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
145-146	Uranus Latitude*, Longitude of Umbriel	deg	E
147-148	Uranus Latitude*, Longitude of Titania	deg	E
149	Range Earth - S/C	km	E
150	Range Sun - S/C	km	E
151	Range Sun - Earth	km	E
152	Range Sun - Uranus	km	E
153	Range Uranus - S/C	km	E
154	Range Uranus - Miranda	km	E
155	Range Uranus - Ariel	km	E
156	Range Uranus - Umbriel	km	E
157	Range Uranus - Titania	km	E

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
158	Angle Earth - Sun - S/C	deg	E
159	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
160	Angle Sun - Earth - S/C	deg	E
161	Angle Uranus - Sun - S/C	deg	E
162	Angle Sun - S/C - Uranus (Celestial Cone Angle of Uranus)	deg	E
163	Angle Sun - Uranus - S/C	deg	E
164	Celestial Clock Angle of Earth	deg	E
165	Celestial Clock Angle of Uranus	deg	E
166-167	Celestial Clock and Cone Angles of Miranda	deg	E
168-169	Celestial Clock and Cone Angles of Ariel	deg	E
170-171	Celestial Clock and Cone Angles of Umbriel	deg	E

Attachment I

Fixed Instrument SEDR Format
Uranus Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
172-173	Celestial Clock and Cone Angles of Titania	deg	E
174-175	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
176-177	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
178-179	Right Ascension and Declination of Uranus, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
180-181	Right Ascension and Declination of S/C, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
182-183	Right Ascension and Declination of Sun, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
184-185	Right Ascension and Declination of Miranda, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
186-187	Right Ascension and Declination of Ariel, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
188-189	Right Ascension and Declination of Umbriel, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
190-191	Right Ascension and Declination of Titania, Uranus Centered, Uranus True Equinox and Equator of Date	deg	E
192-193	Celestial Latitude* and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

* Planetocentric latitude

Attachment I

Fixed Instrument SEDR Format Uranus Encounter Navigation Block

* Planetocentric latitude

ATTACHMENT J

**Fixed Instrument SEDR Format
Neptune Encounter Navigation Block**

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
1	SCET UTC Year of Navigation Data Block	years, AD	I
2	SCET UTC Day of Navigation Data Block	day of year	I
3	SCET UTC Hour of Navigation Data Block	hour of day	I
4	SCET UTC Minute of Navigation Data Block	minute of hour	I
5	SCET UTC Second of Navigation Data Block	second of min	I
6	SCET UTC Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Triton Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of S/C, Nereid Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
37-42	Cartesian State of S/C, Satellite X Centered, Earth Mean Ecliptic and Equinox of 1950.0 (Spare Words)	km km/sec	E
43-48	Cartesian State of S/C, Satellite Y Centered, Earth Mean Ecliptic and Equinox of 1950.0 (Spare Words)	km km/sec	E
49-54	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of Neptune, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
61-66	Cartesian State of Earth, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
67-72	Cartesian State of Triton, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
73-78	Cartesian State of Nereid, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
79-84	Cartesian State of Satellite X, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
85-90	Cartesian State of Satellite Y, Neptune Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
91-96	Cartesian State of S/C, Neptune Centered, Neptune Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
97-102	Cartesian State of Triton, Neptune Centered, Neptune Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
103-108	Cartesian State of Nereid, Neptune Centered, Neptune Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
109-114	Cartesian State of Satellite X, Neptune Centered, Neptune Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
115-120	Cartesian State of Satellite Y, Neptune Centered, Neptune Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
121-126	Cartesian State of S/C, Neptune Centered, Neptune True Prime Meridian and Equator of Date	km km/sec	E
127-129	Cartesian Position of Triton, Neptune Centered, Neptune True Prime Meridian and Equator of Date	km	E
130-132	Cartesian Position of Nereid, Neptune Centered, Neptune True Prime Meridian and Equator of Date	km	E
133-135	Cartesian Position of Satellite X, Neptune Centered, Neptune True Prime Meridian and Equator of Date	km	E
136-138	Cartesian Position of Satellite Y Neptune Centered, Neptune True Prime Meridian and Equator of Date	km	E
139-140	Neptune Latitude*, Longitude of S/C	deg	E
141-142	Neptune Latitude*, Longitude of Triton	deg	E
143-144	Neptune Latitude*, Longitude of Nereid	deg	E

* Planetocentric latitude

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
145-146	Neptune Latitude*, Longitude of Satellite X	deg	E
147-148	Neptune Latitude*, Longitude of Satellite Y	deg	E
149	Range Earth - S/C	km	E
150	Range Sun - S/C	km	E
151	Range Sun - Earth	km	E
152	Range Sun - Neptune	km	E
153	Range Neptune - S/C	km	E
154	Range Neptune - Triton	km	E
155	Range Neptune - Nereid	km	E
156	Range Neptune - Satellite X	km	E
157	Range Neptune - Satellite Y	km	E

* Planetocentric latitude

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
158	Angle Earth - Sun - S/C	deg	E
159	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
160	Angle Sun - Earth - S/C	deg	E
161	Angle Neptune - Sun - S/C	deg	E
162	Angle Sun - S/C - Neptune (Celestial Cone Angle of Earth)	deg	E
163	Angle Sun - Neptune - S/C	deg	E
164	Celestial Clock Angle of Earth	deg	E
165	Celestial Clock Angle of Neptune	deg	E
166-167	Celestial Clock and Cone Angles of Triton	deg	E
168-169	Celestial Clock and Cone Angles of Nereid	deg	E
170-171	Celestial Clock and Cone Angles of Satellite X	deg	E
172-173	Celestial Clock and Cone Angles of Satellite Y	deg	E

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
174-175	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
176-177	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
178-179	Right Ascension and Declination of Neptune, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
180-181	Right Ascension and Declination of S/C, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
182-183	Right Ascension and Declination of Sun, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
184-185	Right Ascension and Declination of Triton, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
186-187	Right Ascension and Declination of Nereid, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
188-189	Right Ascension and Declination of Satellite X, Neptune Centered, Neptune True Equinox and Equator of Date	deg	E
190-191	Right Ascension and Declination of Satellite Y, Neptune Centered, Neptune True Equinox and Equator of date	deg	E

Attachment J

Fixed Instrument SEDR Format
Neptune Encounter Navigation Block

SEDR WORDS	DESCRIPTION	UNITS	TYPE
192-193	Celestial Latitude* and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
194-195	Celestial Latitude* and Longitude of Earth, Sun Centered Earth True Equinox and Ecliptic of Date	deg	E
196-197	Celestial Latitude* and Longitude of Neptune, Sun Centered Earth True Equinox and Ecliptic of Date	deg	E
198	Time To (-) / From (+) Neptune Periapsis Passage	sec	E
199-252	Spares		

* Planetocentric latitude